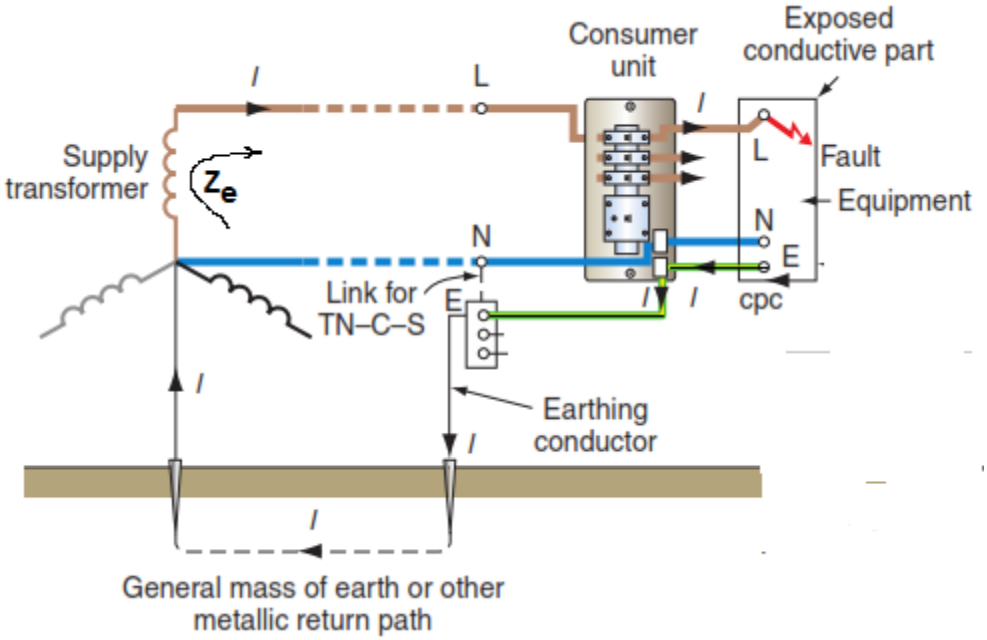
Protective earthing, protective conductor and automatic disconnection in case of a fault (Fault protection)



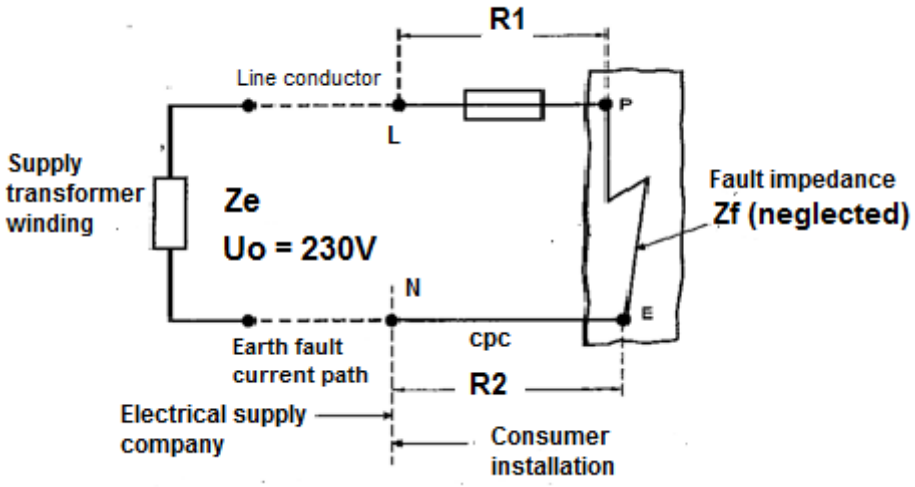


Fig.1 Earth fault loop path.

Figure 1 shows the earth fault system which provides Fault protection. The low impedance path for fault currents, the earth *fault loop path*, comprises that part of the system external to the installation, i.e. the impedance of the supply transformer, distributor and service cables Ze , and the resistance of the line conductor R_1 and circuit protective conductor (cpc) R_2 of the circuit .

The total value of loop impedance *Zs* , of the circuit concerned is therefore the sum of these values:

$$Z_s = Z_e + (R_1 + R_2)\Omega$$

External loop impedance Z_e

The designer obviously has some measure of control over the values of R_1 and R_2 , but the value of *Ze* can be selected from the following table:

Table 15-1

TT system	21 Ω
TN-S system	0.8 Ω
TN-C-S system	0.35 Ω

Example1

A single-phase circuit is run in single-core 70ºC pvc-insulated and sheathed cables clipped direct and not bunched with cables of other circuits. Protection against indirect contact is provided by a device of a type listed earlier in lecture 12. If the conductors are copper, the cross-sectional area of the live conductors is 4 mm^2 and that of the protective conductor is 2.5 mm^2, l is 45 m and the supply being PME or TN-c-s system, what is the earth fault loop impedance?

Answer

The relevant table is Table (3-23) so that the value of (R1+R2) / km in ohms /km is obtained from Column 2 in Table 3-23. It is found to be 11.04 ohms / km.

From table 15-1 , for TN-C-S system , Ze = 0.35 ,hence

$$Z_s = 0.35 + \left(\frac{45 \times 11.04}{1000}\right)\text{ohm} = 0.845\text{ohm}$$

Example 2: A 10 mm^2 PVC sheathed PVC insulated copper cable is short-circuited when connected to a 400V supply. The impedance of the short-circuit path is 0.1Ω.Calculate the maximum permissible disconnection time and show that a 50 A Type B MCB depicted in Fig. 2 will meet this requirement.
Solution:

$$I = \frac{V}{Z}$$

$$I = \frac{400}{0.1} = 4000A$$

$$\therefore Fault\ current = 4000A$$

For PVC sheathed copper cables, a value for k of 115. So,

$$t = \frac{k^2 S^2}{I^2}$$

$$t = \frac{115^2 x 10^2}{4000^2} = 82.66 \text{ x } 10^{-3}\ s$$

The maximum time that a 4000 A fault current can be applied to this 10 mm2 cable without dangerously raising the conductor temperature is 82.66 ms. Therefore, the protective device must disconnect the supply to the cable in less than 82.66 ms under short-circuit conditions.

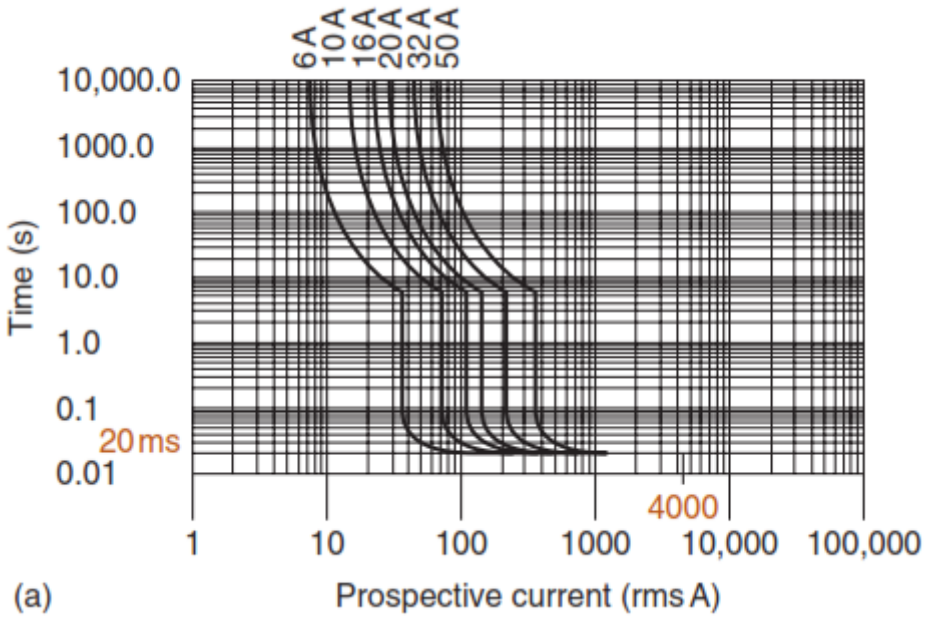


Fig. 2 Time/current characteristics of a Type B MCB.

Figure 2 shows the time/current characteristics for a Type B MCB. This graph shows that a fault current of 4000 A will trip the protective device in 20 ms. Since this is quicker than 82.66 ms, the 50 A Type B MCB is suitable and will clear the fault current before the temperature of the cable is raised to a dangerous level.

Size of the earthing conductors for equipment

The following table2 gives the minimum size of the earthing conductors for electrical equipment (luminaires ,motors ,socket outlets etc.....).

Table-2

Cross sectional area of the phase conductor supplying equipment (mm^2) S	**Minimum cross section of the earthing conductor required S_E (mm^2)**
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	S/2

The principle of the residual current device RCD

The RCD is a circuit breaker which continuously compares the current in the phase with that in the neutral. The difference between the two (the residual current) will he flowing to earth, because it has left the supply through the phase and has not returned in the neutral (see {Fig.3}). There will always be some residual current in the insulation resistance

and capacitance to earth, but in a healthy circuit such current will be low, seldom exceeding 2 mA.

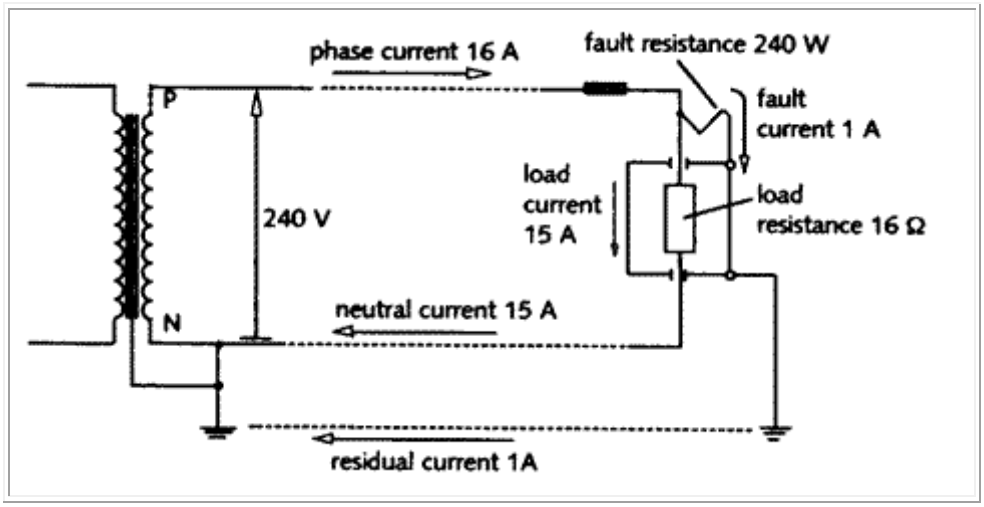


Fig.3 The meaning of the term residual current

The purpose of the residual current device is to monitor the residual current and to switch off the circuit quickly if it rises to a preset level. The arrangement of an RCD is shown in simplified form in {Fig.4}. The main contacts are closed against the pressure of a spring, which provides the energy to open them when the device trips. Phase and neutral currents pass through identical coils wound in opposing directions on a magnetic circuit, so that each coil will provide equal but opposing numbers of ampere turns when there is no residual current. The opposing ampere turns will cancel, and no magnetic flux will be set up in the magnetic circuit.

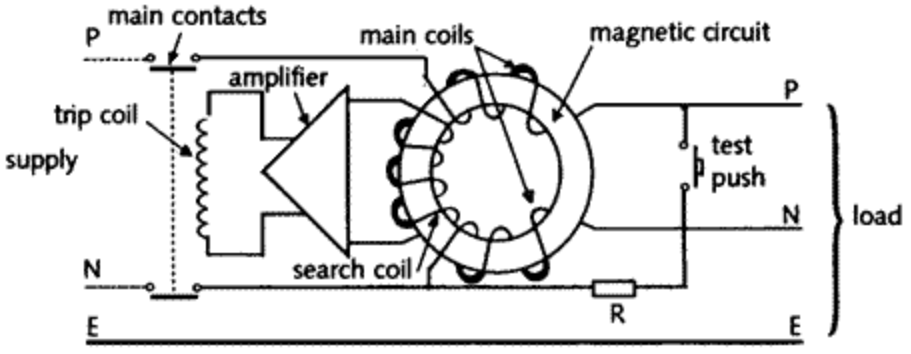


Fig.4